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CHESTNUT OAK IN THE SOUTHERN APPALACHIANS.

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CHESTNUT OAK IN THE SOUTHERN APPALACHIANS.

INTRODUCTION.

Chestnut oak is constantly becoming more valuable as a timber tree because its wood is being used as a substitute for white oak. It is already utilized for many purposes for which white oak alone was formerly deemed suitable; in fact, the best grades of sawed chestnut oak are now mixed with white oak lumber and sold under the name of the more valuable wood. In western Virginia half of the cross-ties on local railroads are chestnut oak, where white oak was once the only wood accepted; in Tennessee and western North Carolina the chestnut oak tie is being more and more used, as white oak there becomes scarcer and dearer. In northern factories, also, the wood is being put to uses for which only a few years ago white oak was considered essential, as for furniture, farm implements, tool handles, oil barrels, interior finish, and wagon stock. Furthermore, with the diminishing of the supply of the better grades of chestnut oak, lumbermen are exploiting the poorer timber left in inferior stands, with the result that chestnut oak forests which until a short time ago were regarded as useful only for the tanning material in their bark have acquired a value for lumber.

DISTRIBUTION.

BOTANICAL DISTRIBUTION.

The botanical range of chestnut oak extends from southern Maine, the valley of the Genesee in New York, and the Bay of Quinte, Ontario, southward to northeastern Maryland, and, following the trend of the Southern Appalachians, through the western portions of Virginia and the Carolinas, as far south as northern Georgia and Alabama. It embraces the country as far west as central Kentucky and western Tennessee.

COMMERCIAL DISTRIBUTION.

The region of the greatest abundance of the tree, and of its largest usefulness for timber and bark, is in the Appalachians and Alleghenies from south-central Pennsylvania southward, through Virginia, West Virginia, and Kentucky, to central and eastern Tennessee

and western North Carolina. Chestnut oak is cut for timber, more or less extensively, throughout its entire range, but the bark, for tanning, is made use of only in those localities where the tree is sufficiently abundant to justify the erection of tanneries or where its bark can be used in connection with that of hemlock. To the north of the region of greatest abundance, in southern New York, chestnut oak is occasionally of some commercial importance, but in New England it is relatively scarce and is put to no special use. To the south, in northwestern Georgia and in northern Alabama, the area of commercial distribution is small and the species is furthermore confined to upper slopes and ridges, where, as the timber is very inferior, the tree is seldom cut except for bark. In the Piedmont region of the Carolinas it is too infrequent to have any specific uses.

PRESENT STAND.

By far the greater portion of the present stand of chestnut oak is restricted to the poorer sites, on which it attains only small dimensions and yields a timber of such poor quality as to be merchantable for only the lowest grades of lumber. Much of the timber is too small and defective for sawed lumber of any sort, although it is suitable for cross-ties. Even on the best sites chestnut oak is smaller than either white or red oak, and its wood is subject to more defects.

The following statement of the present stand of chestnut oak includes the timber which is suitable for lumber and does not embrace that which would be useful only for ties:

	Board feet.		Board feet.
Alabama	49, 600, 000	Tennessee	788, 135, 000
Georgia	46, 500, 000	Virginia	534, 100, 000
Kentucky	1, 216, 900, 000	West Virginia	2, 262, 800, 000
Maryland	12, 000, 000		
North Carolina	422, 175, 000	Total	5, 352, 985, 000
South Carolina	20, 775, 000		

Undoubtedly a large portion of the low-grade timber will eventually become merchantable for lumber as the requirements for saw timber become less rigid.

The amount of bark in the same stands, estimated on a basis of seven-eighths of a cord of bark for each thousand board feet of lumber—a proportion calculated for an average tree of 16 inches diameter—is shown in the following table:

	Cords (long tons).		Cords (long tons).
Alabama	43, 400	Tennessee	689, 600
Georgia	40, 700	Virginia	467, 300
Kentucky	1, 064, 800	West Virginia	1, 980, 000
Maryland	10, 500		
North Carolina	369, 400	Total	4, 683, 900
South Carolina	18, 200		

CHARACTER OF THE REMAINING STAND.

In the valley counties of Virginia, in Maryland, and in northeastern West Virginia the chestnut oak is principally small second growth. The bodies of old timber are small, have been heavily culled, or are at a great distance from means of transportation. On account of the strong demand for both bark and small-sized timber in this region second growth is usually cut as soon as it is large enough to be merchantable. Both lumbering and bark peeling have been important industries in this section for many years and the diameter limit of cutting is smaller than elsewhere.

In central and southern West Virginia 60 per cent or more of the chestnut oak is virgin. Much of the timber in the coves here is of large size and is suitable for board lumber. In central Tennessee and northern Alabama about 45 per cent is virgin, as it has been logged much less heavily than the other oaks. In northeastern Tennessee and western North Carolina, where a large proportion of the slope timber of the higher mountains is chestnut oak, about 50 per cent of the timber is virgin. In South Carolina practically all the chestnut oak is virgin.

The tree is abundantly distributed through eastern Kentucky, and a large portion of the stand is virgin growth of good quality. It is marketed with white oak, although the average grade of the lumber is much poorer than that from the white oak of the region.

The logs cut from virgin timber in the mountains of Tennessee and North Carolina average only 17 inches in diameter at the small end. At an average length of 12 feet such logs would scale only 127 board feet. In South Carolina the average size of mature virgin trees is about 17 inches in diameter on the stump. Chestnut oak in Georgia occurs almost exclusively on the ridges, and is a gnarly, stumpy tree. The larger trees, which are occasionally found in the coves and hollows, are usually hollow and worthless for lumber. The average size of the logs cut is, at present, 17 inches at the small end. It is exceptional for a log to measure 24 inches at the butt. Usually only one log can be cut from trees on the upper slopes and ridges, owing to the short bodies, knotty tops, hollow butts, or other defects. The largest, best, and soundest hardwood timber in the region over which chestnut oak is distributed is on and near the Allegheny Mountains, in eastern West Virginia. Chestnut oak forms only a small proportion of this mixture, however, and its total stand is not large.

The chestnut oak of central Tennessee is comparatively sound, being usually graded and sold as white oak. The average grades of sawed lumber in this district are as follows:

	Per cent.
Firsts and seconds	24
Commons	39
Shipping culls	22
Mill culls	15

In northeastern Tennessee the grades are lower, averaging as follows:

	Per cent.
Firsts and seconds	5
Commons	10
Shipping culls	60
Mill culls	25

The percentage of grades in Buncombe County, N. C., is about as follows:

	Per cent.
Firsts and seconds	10
Commons	30
Shipping culls	40
Mill culls	20

In most of the counties of southwestern Virginia the chestnut oak in the coves is unusually sound, and much lumber of first-class export grades is cut and shipped to Europe with white oak. Except in the coves and most favorable slope sites, however, the timber is small and defective.

THE WOOD AND ITS USES.

QUALITIES.

The wood is heavy, strong, hard, rather tough, close grained, and durable in contact with the soil. It is inclined to check in drying. It is dark brown in color, with the sapwood lighter. As it is somewhat softer than white oak, it does not take so high a polish; and since the pith rays are not so broad as those of white oak the quarter-sawed wood does not present as pleasing silver grain. It is somewhat lighter in weight than the other common kinds of oak. The weight of dried lumber is about 4,000 pounds per thousand feet board measure, while that of white, red, and black oak is about 4,250 pounds. It is considered quite as durable in contact with the soil as white oak, and much more so than any of the red or black oaks.

MOST COMMON DEFECTS.

The most frequent defect of chestnut oak lumber is the discoloration or streaks caused by the burrowing of a minute larva. When the lumber is first sawed these holes are not noticeable, as they are very small, and in addition, perhaps, filled with sawdust. As the lumber

dries, however, they appear as black specks, which spread into larger spots, and often reduce a first or second grade board to a cull. Windshake—another common defect—renders considerable portions of the trunks of many large trees hollow. The loss from these defects is estimated at 15 per cent.

In eastern Tennessee often 75 per cent of the timber is wormy, and fit only for railroad ties, bridge timbers, or car stock. In central Tennessee the wood is probably freer from defects than elsewhere in the region. The proportion of wormy timber seldom exceeds 20 per cent, and the loss from windshake and other defects is low.

Other imperfections to which the timber is subject are "cat faces," "bird pecks," loose knots, and stains. The total cull from fire is the smallest of any of the southern hardwoods, being usually only 5 per cent or less.

USES.

Chestnut oak is used chiefly for low-grade lumber and for tanning material from the bark. Until 1900 from 85 to 90 per cent of the chestnut oak was cut for the bark alone. The timber, except a small proportion of the best and most accessible trees, was left unused after the bark was peeled. Since 1900 there has been a rapid annual increase in the use of the lumber, but the custom of removing the bark and leaving the wood is still practiced in many sections of Tennessee, North Carolina, Virginia, and West Virginia, where low-grade timber can not be marketed at a profit.

The largest and soundest trees of chestnut oak are usually put to the same uses as white oak—tight barrel staves and graded lumber. It is mixed with the superior wood and marketed with it under the trade name of white oak. Some of the chestnut oak lumber from central Tennessee, extreme southwestern Virginia, and south central West Virginia is sufficiently high in quality for export with the best grades of white oak. On account of its poor silver grain, however, it is seldom quarter-sawed, even in the large sizes. The poorer grades are used locally for framing, sheathing, fencing, and rough building lumber. Some mills make a practice of sawing butt logs into boards for shipment as plain-sawed white oak, and the poorer top logs into framing for local use.

The tie industry is very active in the counties along the Tennessee and Cumberland rivers in Tennessee, where there is direct and cheap transportation by water to northern railroad centers. In these counties, approximately 38,000,000 feet are cut annually for cross-ties, as compared with 3,000,000 for lumber—a proportion of nearly 13 to 1.

Car stock forms another important product of chestnut oak timber in the valley counties of Virginia. Car timbers include planking, dimension stuff of all sizes, and beams as large as 8 by 8 inches. Such

timbers are used for bolsters, framing, sills, sides, and flooring of box and freight cars. These timbers are usually cut to order by mills along the several railroad lines to meet the local demand.

Chestnut oak lumber is also used for mine props, slack barrel staves and headings, bridge timber, switch ties, and fuel. Some of the best car and bridge timber is exported to European markets. Switch ties have a 10-inch face and are 10 inches high and from 9 to 23 feet long.

The bark of chestnut oak is used not only in the tanneries, although the most of it is so utilized, but it is also extensively employed for obtaining tannic-acid extract. It competes as a tanning agent with hemlock bark and chestnut wood. Hemlock bark is improved by combination with chestnut oak bark, to produce a firm leather. Chestnut oak bark extract is also used in combination with chestnut wood tannin extract to give compactness and weight to leather.

Some of the tanning-extract plants buy small wood with the bark on, as the wood itself carries a small percentage of tannin. In this way wood as small as 3 inches in diameter can be used. Peeled wood, however, is not accepted.

The tanneries established throughout the region covered by this report are using an increasingly large amount of chestnut oak bark, while new tanneries are being constructed in the mountains. There is a sufficient amount of chestnut oak standing to supply these tanneries for the present, but at the current rate of consumption all but the trees on the upper slopes and ridges, at present inaccessible, and those of small diameter, will be exhausted in the course of a few years. At a tannery in northwestern Virginia that has been in operation about thirty years the supply of chestnut oak bark has become so depleted in the immediate region that they now accept the bark of other species of oak, although until a few years ago nothing but chestnut oak bark was used.

Only 2 per cent of the entire cut of chestnut oak in northeastern Tennessee is converted into sawed lumber, while 75 per cent is cut only for the bark. Practically no tight cooperage staves are cut here on account of the poor quality of the timber. Ties form 16 per cent of the total cut, car timbers 4 per cent, and bridge timbers and switch ties 1 per cent. In central Tennessee, on the other hand, there is considerable cove and foothill chestnut oak, much larger, sounder, and of better quality than that in the eastern portion of the State. Here sawed lumber forms about a quarter of the total cut, and staves a little larger proportion, while less than 10 per cent is left unused in the woods after being peeled for bark. Cross-ties form 37 per cent of the total cut, car timbers 2 per cent, and switch ties 1 per cent.

YIELD OF LUMBER AND BARK PER TREE.

Trees of chestnut oak usually do not cut as much lumber as those of white oak or red oak of the same height and diameter. This is due partly to the greater number of crooks and other defects, and since chestnut oak is usually not nearly as tall as white oak of the corresponding diameter, there is an even greater discrepancy.

Table 1 presents figures, based on common experience in the mills of the chestnut oak region, that show the actual volume of lumber that may be expected from trees of given heights and diameters.

TABLE 1.—*Used volumes[a] of chestnut oak trees of various diameters and heights.*

Diameter breast-high.	Height (feet).								Diameter of top.
	40	50	60	60	80	90	100	110	
Inches.	*Volume—Board feet.*								*Inches.*
10	15	20	25	.....	.....	.....	.....	.....	8
11	20	25	30	.....	.....	.....	.....	.....	9
12	25	30	40	50	.....	.....	.....	.....	10
13	35	40	50	60	.....	.....	.....	.....	10
14	45	55	65	75	90	.....	.....	.....	11
15	56	65	80	95	115	.....	.....	.....	11
16	70	80	95	115	135	160	.....	.....	12
17	.....	95	115	140	160	185	.....	.....	13
18	.....	110	135	165	185	215	255	.....	13
19	.....	130	160	190	215	245	290	.....	14
20	.....	145	185	220	245	280	325	345	14
21	.....	.....	210	250	280	315	360	385	15
22	.....	.....	235	280	320	355	400	430	16
23	.....	.....	265	315	355	400	445	475	16
24	.....	.....	295	350	400	445	495	530	17
25	.....	.....	.....	385	440	495	545	585	17
26	.....	.....	.....	425	490	550	605	645	18
27	.....	.....	.....	465	540	605	665	710	19
28	.....	.....	.....	510	590	665	730	780	19
29	.....	.....	.....	.....	640	730	795	855	20
30	.....	.....	.....	.....	690	790	865	935	21
31	.....	.....	.....	.....	745	860	940	1,020	21
32	.....	.....	.....	.....	800	930	1,025	1,110	22
33	.....	.....	.....	.....	.....	1,005	1,115	1,210	23
34	.....	.....	.....	.....	.....	1,080	1,210	1,320	23
35	.....	.....	.....	.....	.....	1,160	1,305	1,430	24
36	.....	.....	.....	.....	.....	.....	1,400	1,530	25
37	.....	.....	.....	.....	.....	.....	1,485	1,630	26
38	.....	.....	.....	.....	.....	.....	1,565	1,730	26
39	.....	.....	.....	.....	.....	.....	.....	1,830	27
40	.....	.....	.....	.....	.....	.....	.....	1,930	28

[a] Doyle-Scribner log scale.

Table 2 shows the yield of bark in cords (or long tons) from trees of various diameters in the Southern Appalachian region.

TABLE 2.—*Yield of bark in relation to diameter of tree.*

Diameter breasthigh.	Yield of bark.	Diameter breasthigh.	Yield of bark.	Diameter breasthigh.	Yield of bark.
Inches.	*Cord.*	*Inches.*	*Cord.*	*Inches.*	*Cord.*
10	0.06	17	0.12	24	0.22
11	.06	18	.13	25	.24
12	.07	19	.15	26	.26
13	.08	20	.16	27	.28
14	.09	21	.17	28	.30
15	.10	22	.19	29	.32
16	.11	23	.20	30	.34

SILVICAL CHARACTERISTICS.

TOLERANCE.

The intolerance of chestnut oak is the controlling factor in determining its distribution and abundance. It seldom forms more than 5 per cent, and usually an even lower proportion, of the stand in coves where the extremely tolerant hemlock and sugar maple compose larger portions of the stands. As the more tolerant hemlock, beech, and maple are eliminated in the ascent toward the crests, the proportion of chestnut oak steadily increases, until on the higher slopes and ridges it is frequently dominant in the forests. The relatively slow growth of chestnut oak adds importance to the factor of intolerance in limiting its successful competition with shade-enduring trees and restricting its greatest success to open and sunny slopes and ridges. Young seedlings are found under the shade of a fairly dense overhead canopy, if the light is not further weakened by undergrowth, but rarely under the dense cover of saplings and poles in second growth. Sprouts, especially from old, well-established stools, are more tolerant than seedlings, and make more vigorous growth under favorable light conditions. With growth the demand for light rapidly increases. In the sapling and small pole stages at least one-half the full overhead light is necessary, and in the large pole stage practically full overhead light is required. Chestnut oak, however, exhibits the persistence of white oak, though to a less degree. Saplings stunted by many years under dense shade often recover and become fairly vigorous when the shade is removed. In many cases, however, the crowns of such trees are dead-topped and the growth permanently stunted.

ALTITUDE.

Chestnut oak grows in the extreme southern portion of its region up to elevations of 4,500 feet. In North Carolina it is not abundant enough for commercial utility above 4,000 feet, while still farther north, in northern West Virginia and western Maryland, the commercial limit is not more than 3,500 feet. In the extreme northern portion of the region it is widely distributed over the valleys and foothills at the lowest elevations, wherever the soil conditions are favorable; in the extreme southern portion, in northern Georgia and Alabama, it is not common below 2,000 feet elevation.

TOPOGRAPHIC SITUATIONS.

Chestnut oak is the hardiest of all the hardwoods of the Southern Appalachians in regard to topographic requirements. It grows, as has been said, in greatest abundance on exposed upper slopes and ridges, where it is usually the dominant species in the forest and often forms 25 to 35 per cent of the stands. On the lower slopes and in the coves or bottoms it seldom forms more than 10 per cent, and frequently less than 3.

ASSOCIATES.

Black oak and chestnut are the chief associates of chestnut oak. White oak, the hickories, and yellow poplar occur with it to a less extent. Chestnut oak seldom forms a larger proportion of the stand than either chestnut or black oak.

TABLE 3.—*Composition of forests in which chestnut oak forms more than 10 per cent of the mixture—Southern portion of the region—Virgin growth.*

[Trees 10 inches and over in diameter breasthigh.]

Species.	Slope type.				Ridge type.	
	Average of 738 acres.[a]		Average of 262 acres.[b]		Average of 62 acres.[c]	
	Number of trees.	Per cent.	Number of trees.	Per cent.	Number of trees.	Per cent.
Chestnut oak	6.02	16.91	7.46	16.98	12.54	24.34
Black oak	5.02	14.11	6.33	14.41	8.04	15.60
Chestnut	13.65	38.35	8.73	19.88	14.67	28.47
White oak	1.56	4.38	6.09	13.87	.93	1.81
Shortleaf pine	1.82	5.11	.60	1.37	.....	.....
Scrub pine	.85	2.39	.33	.75	.....	.....
Hickory	.82	2.30	3.14	7.15	.....	.....
Gums	1.01	2.84	2.37	5.40	.....	.....
White pine	1.67	4.69	.20	.46	.....	.....
Yellow poplar	.71	2.00	1.84	4.19	1.01	1.96
Maples	.55	1.55	3.55	8.08	4.51	8.77
Hemlock	.24	.67	.12	.27	.....	.....
Basswood	.11	.31	.42	.96	.....	.....
Birch	.07	.20	.24	.55	.15	.29
Buckeye	.02	.06	.13	.29	.....	.....
Cherry	.01	.03	.04	.09	.....	.....
Beech	.....	.....	1.20	2.73	.14	.27
Locust	.....	.....	.28	.64	.....	.....
Other species	1.46	4.10	.85	1.93	[d]9.53	18.49
Total	35.59	100.00	43.92	100.00	51.52	100.00

[a] Polk and Monroe Counties, Tenn.
[b] Scott, Campbell, and Anderson Counties, Tenn.
[c] Harlan County, Ky., and Lee County, Va.
[d] Includes beech, gums, hickory, and locust.

TABLE 4.—*Composition of forests in which chestnut oak forms more than 10 per cent of the mixture—Central and northern portions of the region.*

[Trees 10 inches and over in diameter breasthigh.]

Species.	Virgin slope type (average of 79.5 acres[a]).		Second growth slope type (average of 22 acres[b])		Slope type (average of 20 acres[c]).	
	Number of trees.	Per cent.	Number of trees.	Per cent.	Number of trees.	Per cent.
Chestnut oak	17.74	36.35	6.96	19.95	4.25	9.30
Black oaks	4.30	8.81	8.14	23.34	6.00	13.12
White oak	.75	1.54	7.59	21.76	8.30	18.16
Chestnut	14.98	30.69	4.93	14.13	2.00	4.38
White pine	.....	.....	1.11	3.18	16.85	36.87
Scrub pine	.....	.....	1.60	4.59	3.20	7.00
Pitch pine	3.35	6.87	.75	2.15	2.05	4.49
Hickory	1.72	3.52	1.75	5.02	.30	.66
Gums	1.56	3.20	.24	.69	.25	.55
Maples	.49	1.00	.43	1.23	.40	.87
Hemlock	.36	.74	.....	.....	.05	.11
Yellow poplar	1.45	2.97	.28	.80	.15	.33
Beech	.64	1.31	.....	.....	.....	.....
Basswood	.42	.86	.....	.....	.....	.....
Locust	.60	1.24	.19	.55	.20	.44
Butternut	.01	.02	.14	.40	.....	.....
Birch	.19	.39	.15	.43	1.60	3.50
Other species	.24	.49	.62	1.78	.10	.22
Total	48.80	100.00	34.88	100.00	45.70	100.00

[a] Logan County, W. Va. [b] Northern Virginia and western Maryland. [c] Western Maryland.

SOIL AND MOISTURE REQUIREMENTS.

Chestnut oak reaches its largest and best development in the deep, moist soil of the coves; but it will not endure the slightest excess of soil moisture, and its distribution abruptly ceases on soil at all wet or sour. It can grow, however, in shallower soil than any other species with which it is associated, and does well on rocky slopes. Although its growth is very slow in such situations, it attains commercial proportions even on ridges where, owing to the shallowness and dryness of the soil and the exposed position, other species are unable to thrive. The roots are never deep-seated, and on shallow, rocky soil are superficial and extend laterally to a great distance from the tree, clinging closely to the rocks. Even in the very dry, shallow, and almost pure sand soil along the summit of the main Cumberland Ridge, chestnut oak forms a considerable part of the forest, being the principal hardwood, in mixture with pitch pine.

SELF-PRUNING.

The comparative intolerance of chestnut oak exerts a great influence upon the natural pruning of the tree, as is shown by the variations in time and in thoroughness of the process under different site conditions. Under the conditions in which chestnut oak is most frequently found, on sunny slopes and ridges, in pure groups or with intolerant black oaks and pines, the pruning begins rather late and is seldom well advanced before the large-pole stage. While the trees are saplings the lower limbs and twigs endure considerable side shade and often persist under a moderately dense canopy. In the large-pole stage pruning progresses steadily. The lower limbs are gradually killed and the crown is confined to the upper branches which enjoy full light. Frequently, however, small living branches and dead stubs persist on the lower stem until late in the life of the tree. When the tree grows on a less exposed and deeper soiled site, where it has to compete with closer stands of tolerant species, vigorous pruning begins early in life.

The mature stems are, as a rule, well pruned, especially in the dense cover forests, where they are often as smooth as those of chestnut. On the ridges dead stubs 4 or 5 feet long and scrubby living branches are fairly common on the lower stems, although, even here, when the trees grow in dense groups the trunks are likely to be smooth and clean. Many mature chestnut oak stems also have numerous knobs and small bumps, due, in part, to slow and defective pruning of small branches. Chestnut oak very seldom develops the sap branches, which often grow in great numbers upon the stems of even the oldest white oaks when they are exposed to the sunlight by thinning.

FORM.

Chestnut oak, as it is most frequently found, on open and exposed ridges and upper slopes, where tree growth is not dense and light is abundant, is more short-bodied, limby, and characterized by a wider spreading crown than any of the associated oaks. Vigorous crown development begins early under these conditions, and heavy side branches are formed at the expense of the main leader. During the sapling and pole stages the stem is rarely straight, but usually more or less curved or bowed by exposure in the open stand. The taper is considerable, usually more pronounced in these early stages than in either white or red oak. The main leader is persistent throughout the sapling and small-pole stages, but in the large-pole stages it usually becomes stunted, or disappears entirely and divides into several stout, ascending forks. In this period the crown is normally long and full, occupying one-half or even two-thirds of the stem. As the tree develops, the lower, more slender branches are killed off and the upper limbs grow rapidly, forming a rather open, wide-spreading, and rugged mature crown.

In the sheltered, deep-soiled coves where chestnut oak is not so abundant, its development is more like that of the white oak. In such localities the tree forms, when mature, a long, full stem, fairly straight, though usually with slight curves and crooks. The crown is shorter and narrower, and more compact and regular than that of the slope and ridge trees. The tendency is to form a low-spreading crown, but this is checked here by dense lateral shade.

GROWTH.

The rate of growth of chestnut oak is slower both in height and diameter than that of any of the associated oaks. This and its intolerance account for its being so largely excluded from the shady coves. Table 6 shows the development of diameter, total height, and clear length of trees in the virgin forest of the slope type in Polk and Monroe counties, Tennessee. The growth, as shown in this table, seems on comparison with measurements made in other portions of the region of slope, ridge, and cove trees to represent about the average rate of growth for virgin timber throughout the region. Second-growth trees and trees which have had more favorable light conditions in culled forests would show much more rapid diameter increment at least.

TABLE 6.—*Total height, clear length, and diameter growth of virgin chestnut oak in Polk and Monroe counties, Tennessee.*

Age.	Diameter breast-high.	Total height.	Clear length.	Age.	Diameter breast-high.	Total height.	Clear length.
Years.	*Inches.*	*Feet.*	*Feet.*	*Years.*	*Inches.*	*Feet.*	*Feet.*
20	1.2	12	5	120	12.0	63	24
30	2.4	19	8	130	13.0	65	24
40	3.4	25	11	140	13.9	67	25
50	4.3	31	13	150	14.9	69	25
60	5.4	36	15	160	15.8	70	26
70	6.5	41	17	170	16.7	72	26
80	7.7	47	19	180	17.5	73	26
90	8.8	52	21	190	18.4	74	27
100	10.0	57	22	200	19.3	75	27
110	10.9	60	23				

RATE OF GROWTH OF SPROUTS AND SEEDLINGS.

Table 7 contains average figures for the rate of growth of seedling sprouts and seedlings of chestnut oak for the first ten years in virgin woods. Two localities were studied—the Cumberland Mountains of Claiborne County, Tenn., and the Holston Mountains, in Sullivan County, Tenn. Separate averages were made for each locality by types.

TABLE 7.—*Height growth of young chestnut oak.*

Age.	Cumberland Mountains, slope and ridge, seedling coppice (101 trees).	Holston Mountains.			
		Slope and ridge, seedling coppice (90 trees).	Slope, root suckers (29 trees).	Cove.	
				Seedling coppice (43 trees).	Seedlings (30 trees).
	Inches.	*Inches.*	*Inches.*	*Inches.*	*Inches.*
1 year	13	12	6	9	5
2 years	30	22	7	21	7
3 years	46	38	8	33	8
4 years	62	61	9	44	9
5 years	76	75	9	53	10
6 years	89	.....	10	59	11
7 years	100	.....	10	64	12
8 years	.....	.....	11	.....	13
9 years	.....	.....	11	.....	13
10 years	.....	.....	12	.....	14

From this table the rate of growth of seedlings and seedling sprouts of chestnut oak in the same locality and type can be directly compared. Such comparisons show the rate of growth of seedling coppice in height to be from three to five times as rapid as that of seedlings. The rate of growth of root suckers is seen to run slightly less than that of seedlings.

SIZES ATTAINED UNDER DIFFERENT CONDITIONS.

The following tabular statement, made from measurements taken in different portions of Tennessee and North Carolina, shows the average height, clear length, and diameter breasthigh of old chestnut oak growing under different conditions. Each measurement is

averaged from a number of trees in the same locality, growing under the same conditions, but, except in the ridge trees measured in Jackson and McDowell counties, N. C., only averages of mature trees above 20 inches are included:

County and State.	Trees growing in coves.			Trees growing on slopes.			Trees growing on ridges.		
	Average height.	Average clear length.	Average diameter.	Average height.	Average clear length.	Average diameter.	Average height.	Average clear length.	Average diameter.
	Feet.	*Feet.*	*Inches.*	*Feet.*	*Feet.*	*Inches.*	*Feet.*	*Feet.*	*Inches.*
Sullivan County, Tenn.	102	42	32	77	35	31	.....	.....	.....
Claiborne County, Tenn.	90	45	32	60	30	24	59	19	22
Perry County, Tenn.	85	40	23	75	30	23	51	20	23
Jackson and McDowell counties, N. C.	81	34	24	.....	.....	.....	[a] 21	7	6

[a] Includes trees with diameters less than 20 inches.

The relation of total height to clear length, showing the extent of self-pruning, is also observable. The relative length of crown on the several types is exhibited, and the greater sizes attained in the cove type than in the slope or ridge type.

The largest dimensions are attained along and west of the Allegheny and Cumberland mountains in West Virginia, Kentucky, and Tennessee. Individual specimens occasionally reach a height of 115 and 118 feet, and maximum diameters of 50 and 52 inches.

REPRODUCTION.

The intolerance of chestnut oak is, beyond doubt, one of the chief reasons why the reproduction of the tree in mixed forests on virgin lands is usually inferior to that of chestnut and of the other oaks, and is sometimes quite lacking. Heavy cutting, therefore, assists reproduction, both by seed and sprout. In competition for cut-over lands, however, the relative tolerance of the contending species is of comparatively less importance than other qualities, especially sprouting capacity, quantity of seed borne, and ease with which it is disseminated, immunity of seed from destruction, and rate of growth in early life. In several of these qualities, also, chestnut oak is inferior to other competing species, especially the black oaks, and is sometimes, especially in the southern portion of its range, excluded by them from the second growth.

Of the reproduction of chestnut oak fully 75 per cent is of sprout origin. In many sections where ground fires are frequent the reproduction is almost wholly of seedling sprouts. Of the different species of oak, chestnut oak and black oak are the most persistent sprouters, and reproduce from stump sprouts after logging more generally and uniformly than white oak.

Trees grown in the open, where the foliage gets plenty of light, and in deep, fertile soil produce seed when 15 to 20 years old. In normally dense woods, however, trees do not begin to bear fruit until they are from 50 to 80 years old, according to the density. Sprouts begin to bear much earlier than trees from acorns, and may produce seed when 5 years old.

All of the oaks are poor and irregular seed bearers, as compared with other species of the region. The amount of seed borne in any year, the frequency of seed years, and the age at which bearing begins, are all directly dependent upon the situation of the tree. When growing in the open in full sunlight, and in deep, fertile soil, the crops are heavier, more frequent, and begin earlier than when the tree grows in denser shade or on poorer soil. A very large proportion of the acorns are destroyed by "worms," rodents, and birds, especially crows and jays. The larvæ of several insects develop in the rich, starchy cotyledons, most of them from eggs deposited in immature acorns. In certain sections where hog ranging is extensively practiced so many acorns are eaten that it has a considerable influence in limiting reproduction. Prolonged dry and hot weather in the late autumn after the acorns are on the ground frequently destroys their germinating power.

The acorns, which require only one season for maturing, ripen and drop from the trees during the early part of autumn, usually beginning about the time of the first frost or just before. Except for such chance dissemination as takes place by means of birds and animals, seed distribution is accomplished by gravity. Large heavy acorns occasionally roll some distance on steep slopes, but most of the seed falls and germinates within a few feet of the trees.

Germination.—The seed of chestnut oak invariably germinates before Christmas, usually in October or early in November, before the ground is frozen; the exact time is dependent largely on the temperature and moisture conditions; moist, warm weather is favorable, and dry, hot or cold weather unfavorable. The development of the seedlings in late fall and early winter is confined almost wholly to the root. The stem rarely protrudes more than one-half inch from the nut before the following spring. The seeds usually germinate lying uncovered where they fall, but a light cover to preserve their moisture is favorable. Fresh, loose soil or well-decomposed leaf litter forms the best germinating bed. When the acorns fall on thick, dry duff or on a mat of newly fallen leaves they may fail to germinate from lack of moisture, or the leaves may prevent the rootlet from reaching the soil. On stony land, suitable conditions are afforded by moist clefts between rocks and crevices around roots. Holes made by hogs

in rooting during the preceding spring or summer also offer favorable situations. From 75 to 95 per cent of the acorns produced are sound and will germinate under proper conditions.

Requirements for thrifty development.—Chestnut oak seedlings are confined largely to the more exposed situations on the upper slopes and ridges, where their exacting light requirements are met; they are largely excluded from the denser forests of the coves, or if they persist, are stunted and make slow growth, except in openings. While deep, loose soil with an equitable moisture supply is favorable to thrifty development, young seedlings grow freely in the thin, dry, rocky soils of the ridges and upper slopes if other conditions, especially light, are favorable. On account of the frequent fires most saplings on the slopes and ridges are seedling sprouts.

Amount of seedling reproduction.—At the extreme southern portion of the region the seedling reproduction of chestnut oak is not good. Both black and red oak are more aggressive and are replacing it in the young stands. In the Tennessee River Valley, on uncut lands, even on the slope and ridge forests, it appears to be giving way everywhere to black and red oak. The same thing is seen less strikingly in the mountains of eastern Tennessee and western North Carolina, where chestnut oak usually forms less than 25 per cent of the second growth stand on the slopes and ridges, although in the virgin forest it sometimes constitutes 30 per cent of the stand. In West Virginia, northern Virginia, and western Maryland, on the other hand, it is one of the aggressive species. It effectually replaces itself in the second growth, and increases its percentage in the forest if other trees are cut at the same time.

SPROUT REPRODUCTION.

In capacity to reproduce by sprouts from the root-collar, chestnut oak ranks next to chestnut among the hardwoods of the slope forest, surpassing the other associated oaks both in the extreme age limit and in the number of vigorous sprouts. Its sprouts grow more slowly, however, than those of the other oaks. A 10 or 12 inch stump will frequently produce 15 or 20 sprouts, from 3 to 6 of which will survive and reach maturity.

Young trees and seedlings of chestnut oak, when they are cut, sprout either from the root-collar or from the stem. The sprouting of older trees from the stump after they are cut down is practically limited to the root-collar. The sprouting capacity is determined more by age and vigor than by size. Under the most favorable conditions of growth, vigorous trees sprout until 150 or even 200 years old, or until they are from 16 to 18 inches in diameter. Stunted trees and those growing under unfavorable conditions, as on thin, rocky soil or high ridges, sprout feebly when more than 120 years old and

12 to 14 inches in diameter. Both small and large trees when top-killed by fire sprout freely from the root-collar. Such sprouting is more vigorous after early spring fires than after late autumn fires. As in the case of cut trees, the vigor of the sprouting of large trees which are fire-killed varies with age and conditions of growth.

In addition to sprouting, the chestnut oak suckers from the roots, especially on thin or stony soil where the roots are superficial. These root suckers are seldom produced unless the roots are exposed or injured, or the parent tree is broken or cut. They are seldom vigorous and they can not be depended upon, like sprouts from the root-collar, for reproduction.

Requirements for thrifty development.—The principal requirement of chestnut oak sprouts for thrifty development is abundant light. Deep, loose, well-watered soil is helpful, but, in general up to the sapling stage, is much less important than light. Hence, as a rule, sprouts develop more vigorously during the first ten years on the slopes and ridges than in the coves, in spite of the better soil conditions there. However, sprouts supported on an ample and vigorous root system are much less sensitive than seedlings to shade during early life.

In order to secure the most vigorous sprouts, stumps should be cut low and smooth, without tearing the bark. The winter and early spring are the best seasons for cutting. Chestnut oak is cut for bark in the spring and early summer, and the earlier cutting promotes the best sprouting.

SUSCEPTIBILITY TO INJURIES.

FIRE.

Chestnut oak is more immune from fire attacks than any other of the important species of the southern mountains. All of the oaks, with their thick, firm bark, are comparatively resistant to fire, both old and young, but chestnut oak, with its particularly rugged bark, is the best protected of them all. Cases of hollowness or other serious fire injury are infrequent except in the most exposed situations. Even in early life the bark is comparatively thick, and surface fires, except during the growing season, do little damage. This, and its excellent sprouting capacity, explain why chestnut oak is usually the last tree to disappear from areas repeatedly burned.

GRAZING.

Over a large part of the woodlands of the southern Appalachian region hogs range more or less freely at all seasons. In the fall they depend almost entirely on mast for their subsistence. The sweet nuts

of chestnuts are devoured first and most completely, while of the oaks the sweeter acorns of white oak and chestnut oak are most sought. The acorns of the black oaks, when other mast is plentiful, are avoided until sweetened by the heavy frosts of late autumn.

Since tender-leaved species such as chestnut are preferred by grazing cattle, the young growth of chestnut oak seldom suffers from this cause except on heavily grazed land.

INSECTS.

Neither the foliage nor twigs of chestnut oak is attacked by any insects which cause serious damage. The wood in the living tree, however, is entered by several insects, their burrowings reducing considerably the commercial value of the timber. One of the most common and destructive of these is the oak timber worm (*Eupsalis minuta* Dru.).

The oak carpenter worm (*Prionoxystus robiniæ* Peck), while more common in red and black oak, attacks chestnut oak also, but not to a very serious extent.

FUNGI.

There are no fungi in this region, so far as known, which attack green, thrifty trees of chestnut oak. As in the case of white oak, however, there are a number of sapwood fungi which attack dead, wounded, or fire-scarred trees, and several of the Polyporus group work in the butts and lower trunks of similarly weakened trees.

ATMOSPHERIC AGENTS.

Chestnut oak is badly affected by windshake. The mature timber ranks next to chestnut in the extent and frequency of this defect. In many sections fully 40 or 50 per cent of the old chestnut oak has to be butted off in the woods on account of windshake. With its widespreading, firm root system, chestnut oak is rarely thrown by storms, however, even on the most exposed ridges.

OLD AGE AND MATURITY.

Perfectly sound, mature specimens of chestnut oak are rarely found, despite its resistance to fire, which would ordinarily be an important factor favoring longevity and continued soundness. Old chestnut oak is very commonly hollow-butted for from 6 to 10 feet, the hollows ranging from 5 to 10 inches in diameter. This hollowness, however, seems to be unconnected with fires, since evidence of a burn can not often be found. Not only do trees which grow in poor, dry, thin soil suffer, but even cove chestnut oak is very often thus affected. This common hollowness, combined with the prevalent windshake and attacks of timber worms, renders old chestnut oak much less hardy and resistant than white oak. In this respect it resembles chestnut.

MANAGEMENT.

On account of its relatively slow growth and the comparatively low value of its timber, the reproduction of chestnut oak should not be favored in situations where other species of greater value, like white oak, reach large size and form high-grade timber. In such situations both seed and sprout reproduction of chestnut oak should be discouraged. This is best done by cutting chestnut oak to the very smallest possible diameter, either during the late summer, when its sprouting powers are lowest, or a year or two in advance of cutting the other timber, that the comparatively dense cover may lessen the sprouting of the chestnut oak and at the same time give the more desirable species an opportunity of seeding.

On poorer soils, however, especially on upper slopes and ridges, chestnut oak should be favored. Since the timber is chiefly adapted for ties and mine props and low-grade lumber, for which trees of relatively smaller size can be used, sprouts should be largely relied upon for reproduction, with some seedlings to replace the sprout stands as they become exhausted.

The diameter limit of cutting for sprout reproduction should not exceed 14 inches, breast high, since beyond that limit the rate of growth of sprouts is slow and the sprouting capacity of the stock begins to lessen. Trees between 12 and 14 inches also yield a large number of first-grade ties with a small percentage of waste in the top. Trees of this size also cut well for bridge timber and car stock, and yield a remunerative weight of tan bark. A 10-inch tree yields only one 6-inch tie; a 12-inch tree yields two 7-inch ties and two 6-inch ties; a 14-inch tree yields three and often four 7-inch ties. If the ties are sawed, a 14-inch tree will also furnish a small amount of low-grade lumber. At a stumpage value of $2 a thousand feet board measure for tie timber, a 10-inch tree would yield about 6½ cents; a 12-inch tree about 18 cents, and a 14-inch tree between 35 and 50 cents.

One of the features of management should be to have the young growth as dense as possible. Cuttings for this reason should be at long intervals, 20 or 25 years when possible. Frequent cuttings break down the young growth. The denser the thickets of young trees the taller and straighter will the stems be, the slighter their taper and longer the clear length. This will increase the amount and value of the lumber from each tree. This dense stand incurs also a high yield from each acre, whereas an open stand gives comparatively low returns. A third advantage of the dense stands is that they shade the soil, preserve the soil moisture, and accelerate the growth of the timber.

Only suppressed sprouts, small stunted trees, and tops should be used for mine props. Nor should sound, thrifty trees be cut for fuel or charcoal.

SUMMARY.

Chestnut oak grows where white oak and other more valuable hardwoods will not thrive, and therefore it has a definite place in southern forests, because of this ability to grow in rocky, exposed situations. It is a tree that should be reckoned with in problems of second growth in the Southern Appalachians,[a] where it forms good protection cover on the steeper slopes. It is likely to maintain its present increasing value for timber, and this fact, together with the use of its bark in tanning, and with the prospect of a still closer utilization of tanning material, gives it importance as a factor in the problem of maintaining the hardwood supply of the country. Because of its sprouting ability and comparatively rapid sprout growth it should be managed as a coppice forest, particularly for the production of ties.

Approved:

JAMES WILSON, *Secretary.*

WASHINGTON, D. C., *November 16, 1907.*

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[a] Forest Service Circular 118, Second Growth in the Southern Appalachians.

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